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Piscoacritia, gen. nov.: First Account of Tribe Trochini (Gastropoda: Trochidae: Trochinae) from the Cenozoic of Western South America

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Abstract. ***Piscoacritia collapsa*** gen. nov., sp. nov., a late Miocene to Pliocene gastropod from forearc marine deposits of southern Peru, constitutes the first known Cenozoic occurrence of the tribe Trochini (Trochidae: Trochinae) from western South America. Its deeply sulcate spiral sculpture distinguishes it from all species of *Trochus,* while its umbilical and columellar structure distinguishes it from all species of *Tectus.* Populations of ***P. collapsa*** lived on rocks and gravel close to the low-tide line in partly sheltered embayments along a desert coast.

INTRODUCTION

Most species of the gastropod family Trochidae Rafinesque, 1815, from the temperate Peruvian Province belong to the subfamily Tegulinae Kuroda, Habe & Oyama, 1971. Only a single example of the subfamily Trochinae Rafinesque, 1815, presently occurs along the coast of Peru and Chile, *Diloma nigerrima* (Gmelin, 1791), a wide-ranging species of the tribe Gibbulini Stoliczka, 1868. The tribe Trochini Rafinesque, 1815, is absent from western South America and, according to Hickman & McLean (1990), it has been absent from the entire eastern Pacific Ocean throughout the Cenozoic. At present, genera of Trochini (e.g., *Trochus* Linnaeus, 1758; *Tectus* Montfort, 1810; and *Clanculus* Montfort, 1810) are restricted to the Indo-Pacific region.

This paper reports the first known Cenozoic occurrence of a species of Trochini from western South America, ***Piscoacritia collapsa*** gen. nov., sp. nov., a deeply sulcate spirally sculptured trochid from southern Peru. Ten mostly complete specimens and numerous fragments have been found in upper Miocene to lower Pliocene bioclastic conglomerates from several localities within the Pisco Basin and 100 km farther south near Sacaco.

GEOLOGY

The Pisco Basin (Figure 1) is an emergent forearc basin with widespread exposures of Eocene through Pleistocene marine sedimentary strata (DeVries, 1998). The youngest depositional sequence preserved in the basin, largely encompassed by the middle Miocene to Pliocene Pisco Formation, consists of bioclastic sandstone and conglomerate from nearshore paleoenvironments and tuffaceous and diatomaceous fine-grained sandstone from offshore paleoenvironments. Bioclastic deposits are frequently exposed lapping onto outcrops of igneous basement rock within the basin and in an outlying smaller basin near Sacaco (Figure 1). A complex paleogeography of steep shorelines and broad embayments can be reconstructed from the distribution of such outcrops near Nazca (DeVries, 1988) and Sacaco (Muizon & DeVries, 1985).

MATERIAL

Trochid specimens were found within the Pisco Basin in the valley of the Río Ica and on the flanks of Cerro Huaricangana, west of Nazca (Figure 2) and farther south along Quebrada El Jahuay and near Sacaco (Figure 3). All specimens were collected by T. DeVries unless attributed to J. Macharé (formerly of the Instituto Geofísico del Perú). Locality-sample numbers are listed in the appendix. Specimens have been deposited at the Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington, USA, and the Laboratorio de Vertebrados, Museo de Historia Natural, Universidad Nacional de San Marcos, Lima, Peru.

Measurements of length (L) and width (W) are reported in millimeters. Dimensions of broken specimens are reported in parentheses. Ages are based on ^{40}K-^{40}Ar and ^{40}Ar-^{39}Ar radiometric dates and microfossils as reported elsewhere (DeVries, 1998). Abbreviations for museums include: UWBM, Burke Museum of Natural History and Culture, University of Washington; MUSM INV, Laboratorio de Vertebrados, Museo de Historia Natural, Universidad Nacional de San Marcos.

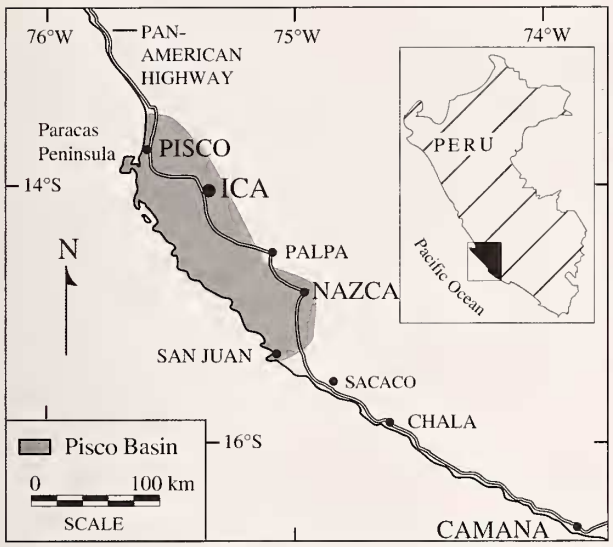


Figure 1. The Pisco Basin, an emergent forearc basin in southern Peru. Localities with specimens of ***Piscoacritia collapsa*** DeVries & Hess, sp. nov. are found near Ica, Nazca, and Sacaco.

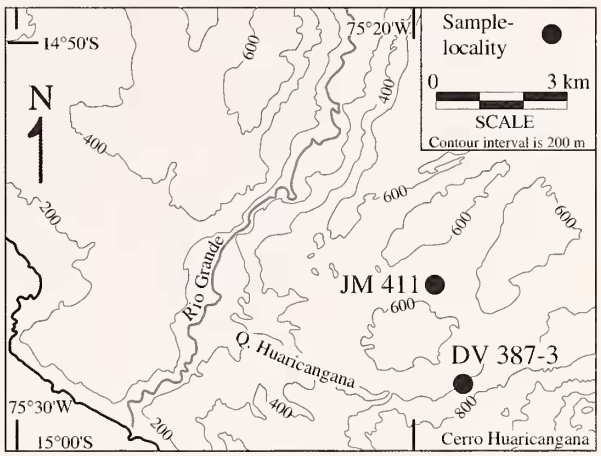


Figure 2. Locality-samples with ***Piscoacritia collapsa*** DeVries & Hess, sp. nov., west of Nazca, within the southern confines of the Pisco Basin.

SYSTEMATIC PALEONTOLOGY

Superfamily TROCHACEA Rafinesque, 1815
Family TROCHIDAE Rafinesque, 1815
Subfamily TROCHINAE Rafinesque, 1815
Tribe TROCHINI Rafinesque, 1815
Genus ***Piscoacritia*** DeVries & Hess, gen. nov.

Type species: ***Piscoacritia collapsa***, sp. nov.

Diagnosis: Sutures appressed to impressed; axial sculpture absent; spiral sculpture of deep sulcus at or posterior to mid-whorl; base weakly excavated; umbilical area with shallow chute; columella angled; columellar plication present, columella disjunct at paries; three umbilical cords present, two ending abapically in weakly bulbous tooth.

Description: As for type species (see below).

Discussion: The presence of toothed umbilical cords on specimens of ***Piscoacritia*** invites comparison with species of the tribe Tegulinae, which are numerous along the western shores of North and South America. Species of Tegulinae from Peru, including modern species and undescribed Pliocene and Miocene species of *Tegula* (*Chlorostoma*) Swainson, 1840, and *T.* (*Agathistoma*) Olsson & Harbison, 1953, differ from ***Piscoacritia*** by having a true umbilicus (if not plugged) and a parietal callus that smoothly joins a weakly keeled, broadly coiled columella with the base of the penultimate whorl, thereby separating the aperture from the umbilicus.

Specimens of ***Piscoacritia*** also were compared with the Californian *Tegula* (*Stearnsium*) *regina* Stearns, 1892, a large conical trochid with a concave base. The Californian species has a small parietal callus that reveals more of the keeled columella than seen in other species of *Tegula*. Nonetheless, the parietal area is not disjunct from the base of the penultimate whorl, as it is in ***Piscoacritia*** and trochinine species. Specimens of *T. regina* and other species of *Tegula* also lack regularly spaced spiral grooves on the base that are present on ***Piscoacritia*** and many trochinine species.

A comparison of ***Piscoacritia*** with other genera of Trochini, particularly *Trochus* and *Tectus*, is complicated by a history of inconsistent descriptions of the trochid umbilicus that has led to contradictory subgeneric and generic assignments of species (Cossmann, 1918; Wenz, 1938). To clarify comparisons, a summary of columellar and umbilical features of selected genera and subgenera of Trochini is presented in Table 1.

Trochus (*Trochus*) has an umbilical pit inside of which is attached a twisted columella. Other subgenera and genera of Trochini with umbilical pits include *Clanculus*, *Infundibulum* Montfort, 1810, and *Infundibulops* Pilsbry, 1889. *Cardinalia* Gray, 1847, has a plugged pit. *Rochia* Gray, 1857, has a tunneling umbilical chute that separates the columella from the base of the penultimate whorl. Both *Cardinalia* and *Rochia* have been designated subgenera of *Tectus* by Thiele (1931), Wenz (1938), Keen & Cox in Knight et al. (1960), and Herbert (1993). *Tectus*, however, has neither an umbilical pit nor chute. It does have a free-standing plication near the base of a short columella. The plication and lack of umbilical recess are diagnostic of *Tectus* in the sense of Cossmann (1918), Wenz (1938), and Sohl (1998). Thus, in accord with Cossmann (1918), *Rochia* and *Cardinalia*, taxa with an umbilical recess and without a free-standing columellar plication, are herein considered subgenera of *Trochus*. This classification is supported in part by genetic data (Borsa & Benzie, 1993).

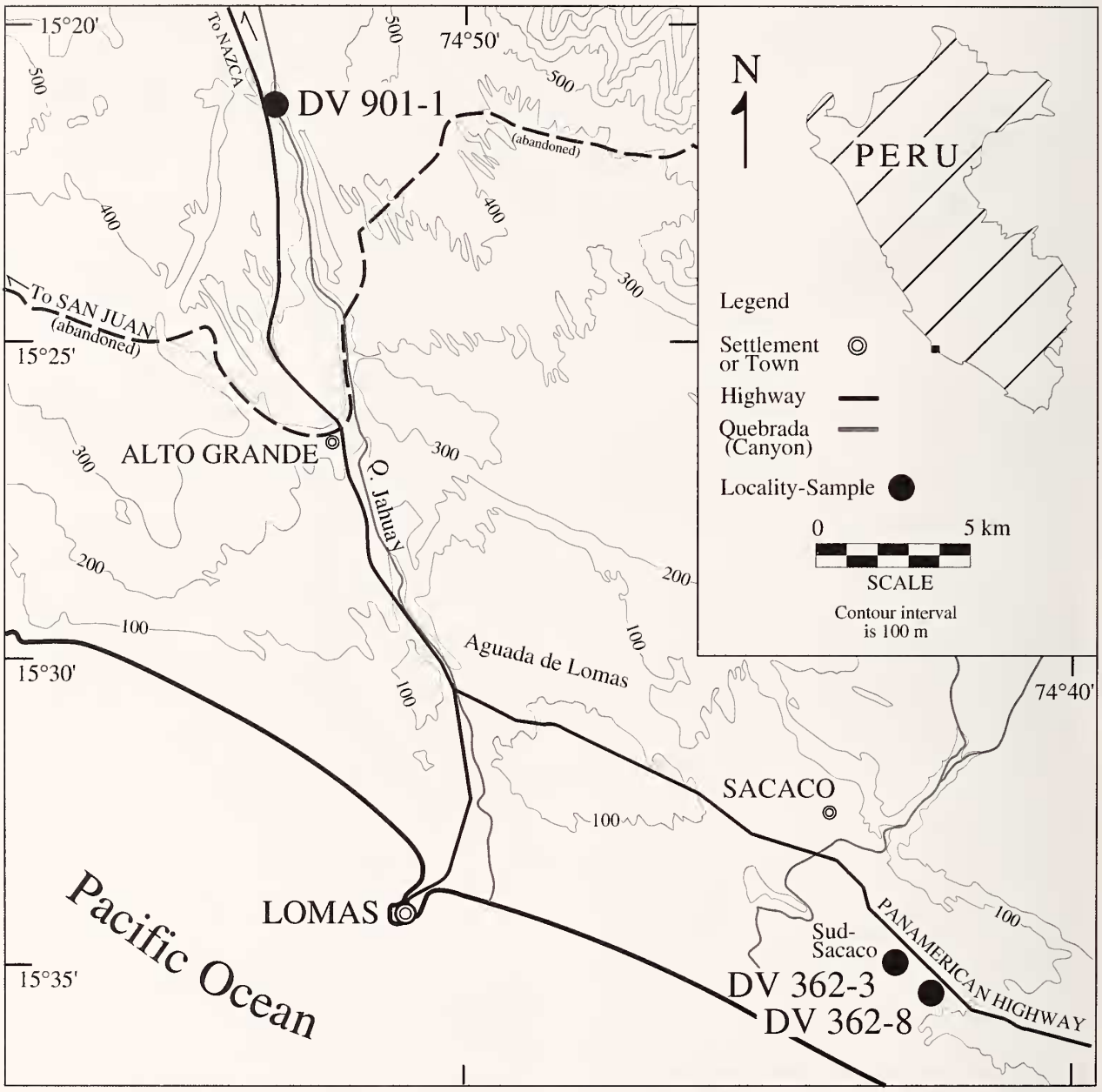


Figure 3. The type locality (DV 901) with sampling number (DV 901-1) for ***Piscoacritia collapsa*** DeVries & Hess, sp. nov., located 10 km north of Alto Grande off the Panamerican Highway in southern Peru. Other *Piscoacritia*-bearing locality-samples near Sacaco are shown.

Piscoacritia is similar to *Trochus* (*Rochia*) in having an umbilical chute that separates the columella from the base of the penultimate whorl, although the chute of the latter is narrower and deeper. ***Piscoacritia***, however, has neither the axial swellings nor the spirally arranged beads that characterize to varying degrees *Trochus* (*Rochia*), other taxa with umbilical recesses (*Clanculus, Infundibulops, Infundibulum, Cardinalia*), and Recent species of *Tectus*. The exclusively spiral sculpture of ***Piscoacritia*** does resemble that of some Cretaceous Caribbean species of *Tectus* (Sohl, 1998) and a middle Miocene species of *Tectus* from Japan (Kobayashi & Horikoshi, 1958).

The columella of ***Piscoacritia*** is in one regard similar to that of *Trochus* (*Trochus*). In *Trochus* (*T.*) *maculatus* Linnaeus, 1758, six spiral cords define a steeply inclined umbilical funnel (i.e., a steeply angulate columella). The innermost umbilical cord twists adapically and attaches inside a deep umbilical pit. Each umbilical cord termi-

Table 1

Comparison of umbilical and columellar characters in selected genera and subgenera of Trochini. Examples of each taxon except *Trochus* (*Infundibulum*) were examined by the author.

Taxon	Umbilical recess	Free-standing columellar plication	Umbilical cords (toothed cords)	Reference with figured specimen
Tectus	No	Yes	No	Sohl, 1998
Piscoacritia gen. nov.	Shallow Chute	Yes	3 (2)	This paper
Trochus (*Rochia*)	Chute	Nearly So	1–2 (1–2)	Abbott & Dance, 1982
Trochus (*Trochus*)	Pit	No	3–7 (2–6)	Herbert, 1993
Trochus (*Cardinalia*)	Plugged Pit	No	2 (1)	Herbert, 1993
Trochus (*Infundibulops*)	Pit	No	1 (1)	Herbert, 1993
Trochus (*Infundibulum*)	Pit	No	1 (1)	Marshall, 2000
Clanculus	Deep Pit	No	No	Herbert, 1993

nates abapically in a swollen tooth except for the outermost cord, which defines the margin of the umbilicus. A similar arrangement is seen in *T.* (*T.*) *nigropunctatus* Reeve, 1861, which has three to four umbilical cords. In ***Piscoacritia***, two closely spaced toothed umbilical cords are present, bounded by an untoothed cord on the umbilical margin. The umbilical funnel is weakly inclined (i.e., the columella is weakly angulate) and the innermost umbilical cord is not attached adapically, but separated from the base of the penultimate whorl by the umbilical chute.

Piscoacritia shares two features with *Trochus* (*Infundibulum*) and *T.* (*Cardinalia*): an excavated base and highly oblique aperture. Marshall (2000) suggested that these characters may be adaptations for surviving exposure to strong wave action.

Etymology: "Pisco," a forearc basin in southern Peru between Pisco and Nazca where the new genus is found; "acer, acris," with the noun suffix "itia," Latin for sharpness, referring to the refractory umbilical lance.

Piscoacritia collapsa DeVries & Hess, sp. nov.

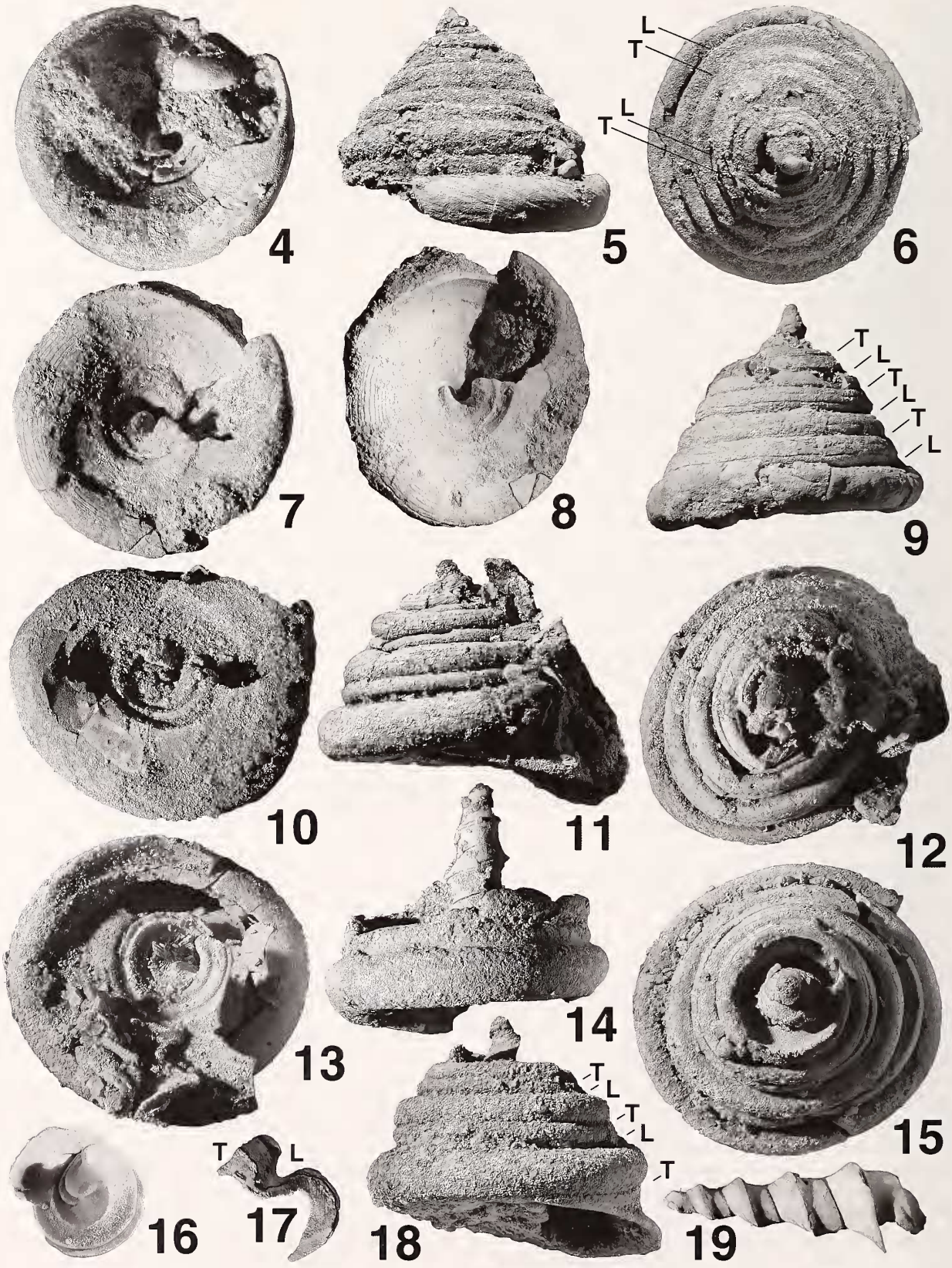
(Figures 4–19)

Description: Shell up to 40 mm wide, conical, broad, spire angle about 65 degrees. Protoconch unknown; teleoconch with up to seven whorls. Axial sculpture absent; thin growth lines strongly prosocline. Spiral sculpture of two moderately to strongly inflated very large convex cords, separated at or posterior to midwhorl by deep canaliculate sulcus that undercuts upper cord; also with several thin incised spiral grooves distributed on two cords in proportion to relative size of cords. Inner edge of outer lip smooth; shell thickest at periphery of two spiral cords and very thin across medial sulcus. Periphery rounded; base excavated, rarely with several spiral grooves on abaxial two-fifths of base. Aperture highly oblique. Umbilical area bordered by raised spiral cord. Columella weakly angulate; with two umbilical cords, each terminating in a weakly bulbous tooth. Columellar plication formed from shelly veneer covering portion of innermost umbilical cord; plication separated from base of penultimate whorl by shallow, expansive umbilical chute. No parietal callus.

Discussion: The most distinctive character of ***Piscoacritia collapsa*** is its deep spiral sulcus (Figure 17). Because the shell is so much thinner at the sulcus, whorls tend to fracture along the sulcus and collapse down upon themselves. The result is a disintegration of the shell during deposition or subsequent compaction, often leaving only a dense umbilical lance (Figure 19).

Variation in ***Piscoacritia*** is largely confined to the position and strength of the spiral sulcus. In some specimens (e.g., UWBM 97367, Figures 7–9), the sulcus is located medially on each whorl. In other specimens (e.g., UWBM 97368, MUSM INV 020, Figures 4–6, 10–12), the sulcus is closer to the posterior suture, producing an anterior cord three to four times larger than the posterior cord. Other intraspecific variation involves the development of spiral grooves. The grooves are not always present on the spire and are usually absent from the periphery and base.

Type locality: Locality DV 901, Quebrada Jahuay, about 100 meters upstream from the crossing of a service road going from the Panamerican Highway to a water well at Jahuay (Figure 3). The type specimen was collected from pebbly sandstone along a dry stream channel lined with a cement retaining wall (locality-sample DV 901-1). Other mollusks from the same strata—*Concholepas kieneri* Hupé, 1854; specimens morphologically intermediate between *Herminespina philippi* (Möricke, 1896) and *Herminespina saskiae* DeVries & Vermeij, 1997; and others intermediate between late Miocene and early Pliocene undescribed species of *Acanthina* (Fischer von Waldheim, 1807)—suggest a late Miocene age for the Quebrada Jahuay site, as do early late Miocene mollusks and radiometrically dated ash beds 10 kilometers south at Alto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Grande that appear to be lower in the section (Muizon & DeVries, 1985).

Etymology: "collapsa," Latin adjective for fallen down, referring to the tendency of the upper spiral cord in each whorl to collapse abapically through the attenuated wall of the spiral sulcus.

Material: UWBM 97367, holotype, DV 901-1, L 22.6 W 25.7; UWBM 97368, paratype, DV 582-1, L 27.1 W 32.3 (specimen deformed; widest diameter); UWBM 97369, paratype, DV 362-8, L 30.1; UWBM 97370, paratype, DV 362-3, L 35.4 W 39.0; UWBM 97371, paratype, JM 411, L 27.0 W (31.8); MUSM INV 020, paratype, DV 582-1, L 31.8 W 37.5; MUSM INV 021, paratype, JM 411, L (22.2) W 29.6; MUSM INV 022, paratype, DV 362-8, W 11.7.

Occurrence: Late Miocene (about 10 Ma) to early Pliocene (about 3.5 Ma), southern Peru.

DISCUSSION

Specimens of ***Piscoacritia collapsa*** usually are found in beds of bioclastic conglomerate that lap onto outcrops of igneous basement rock. The poorly sorted, coarsely bedded, barnacle-rich beds probably accumulated intertidally or subtidally in shallow water. The paleogeography of ***Piscoacritia*** localities (Quebrada El Jahuay, Sud-Sacaco, Cerro Huaricangana, and Quebrada Riachuelo) shows that ***Piscoacritia*** populations were protected behind islands and peninsulas from the full force of Pacific surf (Muizon & DeVries, 1985, DeVries, 1988), which may explain the taxon's persistence despite having a structurally fragile shell.

Sea surface temperatures (SSTs) appear to have been warmer along the coast of southern Peru during the late Miocene and early Pliocene, when ***Piscoacritia*** was present, based on the presence of taxa such as *Dosinia ponderosa* (Gray, 1838) and *Ficus allemanae* DeVries, 1997 (DeVries, 2001). SSTs were probably cooler than they were during the early Miocene when such genera as *Cypraea, Murex, Conus,* and *Terebra* inhabited the southern Peruvian coast (DeVries, 2002).

The biogeographic history of ***Piscoacritia*** prior to its appearance in Peru is unknown. The genus has not been identified in Neogene deposits of Chile (Philippi, 1887; Herm, 1969; S. Nielsen, personal communication, 2002) nor has it been encountered by DeVries in collections of the Museo Nacional de Historia Natural and Universidad de Chile in Santiago, including the collection of J. Tavera. No member of the tribe Trochini has been described from Oligocene or Miocene beds of northern Peru (Olsson, 1931, 1932), Ecuador (Marks, 1951), or Panama (Woodring, 1957). It seems likely that ***Piscoacritia*** would have been introduced from the Indo-Pacific region, as has been the case for several modern mollusks (Emerson, 1978), although the short life span of planktotrophic trochid larvae (Herbert, 1993) poses difficulties for the trans-Pacific scenario. ***Piscoacritia*** successfully colonized protected rocky shorelines of southern Peru for several million years, only to disappear during the late Pliocene extinctions that eliminated 80 percent of marine molluscan species in the Peruvian Province between 3 Ma and 2 Ma (DeVries, 2001).

The late Miocene appearance of ***Piscoacritia*** in Peru is not temporally close to the early to middle Miocene origination of the *Trochus* clade implied by the occurrence of a beaded species of *Trochus* in middle Miocene beds in Japan (Nomura, 1940). The suite of characters shared in part by ***Piscoacritia*** and *Trochus* (*Trochus*) (toothed umbilical cords), *Trochus* (*Rochia*) (an umbilical chute), *Trochus* (*Infundibulum*) (a concave base and highly oblique aperture), and *Tectus* (unbeaded spiral sculpture) makes identifying a most likely sister group problematic pending the discovery of new Miocene species of the tribe Trochini in the Indo-Pacific region.

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Figures 4–19. ***Piscoacritia collapsa*** DeVries & Hess, sp. nov. Labeled features include "L" (sulcus) and "T" (suture). Figures 4–6. MUSM INV 020, paratype, locality-sample DV 582-1. Width is 37.5 mm. Figure 4. Basal view. Figure 5. Lateral view. Figure 6. Apical view. Figures 7–9. UWBM 97367, holotype, locality-sample DV 901-1. Width is 25.7 mm. Figure 7. Basal view. Figure 8. Oblique basal view showing columellar plication and umbilical chute. Figure 9. Lateral view. Figure 10–12. UWBM 97368, paratype, locality-sample DV 582-1. Width is 32.3 mm (widest diameter). Figure 10. Basal view. Figure 11. Apertural/lateral view. Figure 12. Apical view showing whorls fractured along spiral sulcus. Figures 13, 15, 17. UWBM 97371, paratype, locality JM 411. Width is 29.6 mm. Figure 13. Basal view showing continuity of umbilical cords and outer shell layer that includes columellar plication. Figure 15. Apical view showing whorls fractured along spiral sulcus. Figure 17. Cross section of spiral sulcus showing attenuated shell thickness. Magnification about ×3. Figure 14. UWBM 97370, paratype, locality-sample DV 362-3, lateral view. Width is 39.0 mm. Figure 16. MUSM INV 022, paratype, locality-sample DV 362-8, basal view of umbilical lance. Maximum width is 11.7 mm. Figure 18. MUSM INV 021, paratype, locality JM 411, apertural view. Width is 29.6 mm. Figure 19. UWBM 97369, paratype, locality-sample DV 362-8, longitudinal view of umbilical lance. Length is 30.1 mm.

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APPENDIX

List of Locality-Samples

DV 362-3 North end of Sud Sacaco, on east face of depression near the Panamerican Highway. Indurated shell and barnacle beds lapping against northwest side of granite paleo-sea stacks. 15°34′25″S, 74°43′00″W (Yauca 1: 100,000 quadrangle).

DV 362-8 North end of Sud Sacaco, on east face of depression near the Panamerican Highway. Beds of bivalves *Chlamys* and *Choromytilus* lapping against southeast side of granite paleo-sea stacks.

DV 582-1 Along an abandoned road above the eastern wall of Quebrada Huaricangana, south of a series of gulches; indurated bioclastic gravels with oysters. 14°58′23″S, 75°18′34″W (Palpa 1:100,000 quadrangle).

DV 901-1 Quebrada Jahuay, 10 kilometers north of the abandoned crossing of the San Juan de Marcona road with the Panamerican Highway at Alto Grande, and about 100 meters upstream from the crossing of a service road going from the Panamerican Highway to a water well at Jahuay. 15°21′20″S, 74°53′06″W (Acarí 1:100,000 quadrangle).

JM 411 Pampa Salinas, about 7 kilometers northwest of Cerro Huaricangana, 14°56′00″S, 75°19′30″W (Palpa 1:100,000 quadrangle). Collected by J. Macharé.